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Effects of Corn Crop Residue Grazing on Soil Physical Properties and Subsequent Soybean Production in a Corn–Soybean Crop Rotation (A Progress Report)

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Summary

Beginning in 1999, two locations in Iowa (Chariton, Atlantic) were used to study the effects of corn residue grazing by beef cows on soil characteristics and soybean yields the following growing season. Cows were allowed to graze inside selected paddocks at monthly periods throughout the fall and winter. For a grazed and ungrazed comparison, grazing exclosures were used inside the grazed paddocks, while one paddock was left ungrazed for a control. Also, the following year, equal portions of the fields went to no-tillage and disked soil prior to soybean planting so that effects of corn residue grazing on tillage treatments could be compared. The use of this design was to determine whether grazing had adverse effects on soil characteristics and, if so, at what date and weather conditions they occurred. Soil was analyzed for soil bulk density, moisture, penetration resistance, roughness, texture, and type. Corn crop residues were collected for yield, cover, and composition. Precipitation and soil temperature also were recorded throughout the grazing season. The following year, soybeans were harvested using a combine equipped with a yield monitor and global positioning system (GPS).

After two years of study at both locations, some grazing fields with corn crop residue have shown effects on soil and crop residue characteristics. Organic matter (OM) yield of crop residue generally decreases at the faster rate in grazed fields than organic matter of ungrazed fields. However, corn crop residue composition was the same in grazed and ungrazed fields except for the 1999-2000 season at Chariton where crude protein decreased but acid detergent insoluble nitrogen (ADIN) increased with no difference in fiber content between grazed and ungrazed paddocks. Corn crop residue cover and soil roughness both can be greatly affected by the interaction of grazing and weather conditions. When the temperature is above freezing and precipitation is adequate, cattle traffic can cause roughness, while reducing residue cover by working it into the soil. Even though grazing corn residue by cattle can increase the surface roughness, it has not yet caused any increase in bulk density measurements or any reduction in soybean yields. Penetration resistance ratios have shown some significant difference between grazed and ungrazed paddocks, but the reason is unclear.

Introduction

The highest cost to beef cow–calf producers is the feeding of stored feeds in winter months. To lower feed costs, many producers attempt to extend the grazing season into winter. The primary resource for winter grazing in the Midwest is corn crop residue. On average, corn crop residue grazing will reduce the amount of hay needed to maintain cows by approximately a half-ton over winter. Although corn crop residue grazing is quite effective in reducing feed costs, some producers are concerned that it will have an adverse effect on soybean yields the following year due to soil compaction. Studies prove that use of large machinery causes similar soil compaction in wet conditions and reduces corn grain yields from 6–10%. Furthermore, an increase in soil bulk density can occur in overstocked pastures in wet conditions. It is the purpose of this study to determine if corn crop residue grazing affects soil properties and, if so, when and whether grain crop yields will be reduced in subsequent years.

Materials and Methods

Two locations were selected for this experiment, 96 acres belonging to Bill Pellett at Atlantic, Iowa, and 72 acres belonging to Gerald Hansen at Chariton, Iowa. Each location was equally divided into 2 fields for a corn–soybean rotation. Corn was planted in 30-inch rows, and soybeans were drilled in 7-inch rows. Prior to corn planting, fields were chisel-plowed to initiate the experiment with equal tillage treatments. Corn fields then were divided into 4 blocks (12-acre blocks at Atlantic; 9-

acre blocks at Chariton) to determine the effects of cornstalk grazing on yields of soybeans planted with no tillage or disking the year after grazing. Each block contained a lane leading to a common watering and supplementing site for the field. The blocks were equally divided into 6 paddocks for a 28-day rotation throughout the winter grazing period. One paddock in each block was randomly selected to be left ungrazed, as a control. Each of the remaining 5 paddocks was selected for grazing in a specific grazing month (28 days), to evaluate the interactions of corn crop residue grazing and weather conditions on soil characteristics and soybean yields. Prior to grazing, 12 (9-ft^2) grazing exclosures in each grazed paddock were placed in 2 transects at approximately 80–90 ft. intervals for comparison of grazed and ungrazed areas within a paddock.

At initiation of grazing, 12 soil samples per paddock were collected at 0–4 in. and 4–8 in. depths to determine soil moisture, bulk density, and soil classification through soil type, topsoil depth, and slope. Residue cover was measured at 6 locations within each paddock, using the point method. Crop residue samples were collected from one 4-m^2 site in each paddock and composited by block to determine initial residue yield and composition. Crop residue samples also were taken at midpoint and at post-grazing at 1 location within each grazed and ungrazed paddock to determine residue utilization and nutrient loss. Crop residue samples were analyzed for organic matter, crude protein, neutral detergent fiber, acid detergent fiber, acid detergent insoluble nitrogen, and *in vitro* organic matter disappearance (IVOMD).

Throughout the grazing period, soil temperatures were measured with data loggers at a depth of 4 in. every 30 min. at 2 locations per block. Precipitation measurements also were recorded.

Upon completion of the grazing season in spring, soil compaction was evaluated through measurement of soil bulk density and penetration resistance. For the grazed paddocks, measurements were taken inside and also outside, in the same row, 15-feet from each grazing exclosure. Also, 24 measurements were taken within each ungrazed paddock. Soil bulk density and moisture content was determined by weighing and drying core samples from depths of 0–4 in. and 4–8 in. In the same locations, penetration resistance was measured using a penetrometer at 3.5 cm (1.4 in.) intervals to a depth of 28 cm. Soil surface roughness was determined by measuring the length of a 2-m chain forced to take the contour of the soil in 12 locations in each paddock, and also by digital analysis of a 2-m pin meter having 40 pins in 6 locations per paddock. Crop residue cover was measured by the point method in 6 locations per paddock.

In the spring, corn and soybean fields were rotated with the newly drilled soybean fields planted as 2 blocks, with no tillage or disking. Crop residue covers were measured by the point method in 6 locations in each previously grazed paddock. Soybeans were harvested in the fall using a combine equipped with GPS and a yield monitor for taking yield measurements within each paddock. The soybean yields were correlated with date of grazing and tillage treatment to identify any effects of corn crop residue grazing on subsequent soybean production.

Cow body weight was measured at initiation and termination of grazing, and body condition score (BCS) was calculated biweekly. Hay supplementation was provided based on forage availability and on maintenance of a BCS of 5.

In the first year at the Atlantic site, corn was harvested as earlage the week of September 16, 1999. Although it was anticipated that the grazing allowance for each site would be 2.5 acres/cow, harvest of corn as earlage left less corn crop residue, and the residue was of a reduced nutritional quality. As a result, each block was stocked with 3 mature pregnant cows (3.33 cows/acre) on October 18. After 5 paddocks were grazed, cows were removed on March 1. In the second year at Atlantic, corn was harvested as grain crop the week of September 18, 2000. Each block again was stocked with 3 mature pregnant cows (3.33 cows/acre, on October 16) which were removed March 5, 2001, after 5 paddocks were grazed.

In the first year at the Chariton site, corn was harvested as grain on November 8, 1999. Each block was stocked with 3 mature cows (2.5 acres/cow) on November 29. Grazing was terminated on April 13. The second year, corn was harvested as grain the week of November 13, 2000. This year the blocks were stocked with three mature pregnant cows (2.5 acres/cow) on November 21. However, because of muddy conditions around calving time, those cows were removed from the project March 19, 2001 and replaced by non-pregnant cows. The grazing season was completed April 15, 2001. Conventional tillage was the only tillage treatment used prior to soybean planting the second year.

Results and Discussion

Atlantic, Iowa, Location, 1999–2000

Initial corn crop residue yield and composition did not differ between fields. As expected, corn crop residues displayed a significant decrease ($P<0.06$) in dry matter yield between the ungrazed control paddock and the grazed paddocks, a typical result of cornstalk grazing (Table 1). However, corn crop residues in grazed and ungrazed paddocks did not differ in the rates of changes of crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), IVOMD, or ADIN percentages. This indicated that the amount of nutrient loss from grazing was comparable to that lost from weathering effects.

Table 1. Organic matter yields and initial and initial and daily composition changes in ungrazed and grazed paddocks.

		Daily Change		
	Initial Value	Ungrazed	Grazed	Significance
		Atlantic 1999–2000		
OM yield lbs./acre	6219	17.59	-4.12	0.06
% of OM				
IVOMD	46.8	0.019	0.02	NS
NDF	71.9	0	0	NS
ADF	45.6	0	0	NS
CP	4.37	-0.002	-0.006	NS
% of N				
ADIN	20.9	0.04	0.06	NS
		Atlantic 2000–2001		
OM yield lbs./acre	7914.9	-1.48	-10.19	NS
% of OM				
NDF	75.4	0.06	0.06	NS
ADF	45.7	0.03	-0.01	NS
CP	5.5	0	0	NS
		Chariton 1999–2000		
OM yield lbs./acre	4759.5	10.38	-13.46	NS
% of OM				
IVOMD	43.1	0.04	0.001	NS
NDF	74.1	0	0	NS
ADF	46.7	0	0	NS
CP	3.95	0.003	-0.005	0.06
% of N				
ADIN	16.4	0.046	0.087	0.04
		Chariton 2000–2001		
OM yield lbs./acre	4239.4	29.1	-8.02	NS
% of OM				
NDF	77.3	0.002	0.03	NS
ADF	48.1	-0.05	0.04	NS
CP	3.5	-0.002	0	NS

NS = not significant
IVOMD and ADIN for year 2 Chariton and Atlantic have not yet been analyzed.

Corn crop residue covers at the initiation of grazing did not differ between paddocks grazed at different periods (Table 2). Surprisingly, post-grazing ground cover showed no difference in grazed at any date and ungrazed paddocks, which is opposite of the OM yield results. Similarly, post-planting ground cover did not differ between grazed and ungrazed paddocks for either of the tillage treatments (Table 2). However, as expected, post-planting ground covers were greater in soybean fields planted with no tillage than in those planted with disking.

Soil bulk density at the initiation of grazing did not differ between paddocks in either the 0–4 in. and 4–8 in. sampling depths. Final bulk density ratios for 15 ft. outside to inside the grazing exclosures taken on the completion of the grazing season did not differ between the grazed and ungrazed paddocks. Also, the ratio of penetration resistance measurements taken outside and inside grazing exclosures did not differ between grazed and ungrazed paddocks (Figure 1). Soil clay content for topsoil, midsoil, and subsoil were not different when compared between paddocks (Table 3). Both bulk density and penetration resistance measurements with similar soil clay content for all paddocks implies that livestock grazing did not affect soil compaction.

Table 2. Corn crop residue cover pre-grazing, post-grazing, and post-planting.

Initiation Date For Paddock	Pre-Grazing	Post-Grazing	Combined Tillages	No-Tillage	Conventional Tillage
			Atlantic 1999–2000		
Control	87.5	82.3	63.2	79.7	46.8
Oct. 18	84.3	90.3	62.8	81.7	44
Nov. 10	86.3	90.3	62.1	78.6	45.5
Dec. 08	87.6	90.6	62.9	78.4	47.4
Jan. 05	88.1	88.5	62.3	77.3	47.3
Feb. 02	88.2	89.6	61.5	75.3	47.6
			Atlantic 2000–2001		
Control	91.2	86.7	59.6	78.9	40.3
Oct. 16	95.5*	82.4*	56.5	76.7	36.3
Nov. 13	90.9	82.0*	57.3	76.0*	38.5
Dec. 11	93.8*	85.4	54.5	77.7	31.4
Jan. 08	90.6	86.4	51.5*	74.9*	28.1
Feb. 05	91.3	86.2	50.6*	74.1*	27.2
			Chariton 1999–2000		
Control	90	85	66	87.6	44.3
Nov. 29	84.8	66.1*	49.4*	74.5	24.25*
Dec. 28	82.6	62.5*	48.6*	74.5	22.6*
Jan. 25	85.5	69.9*	50.5*	76.5	24.4*
Feb. 22	82.8	64.3*	47.2*	65.8	28.6*
Mar. 21	85.1	63.2*	55.5*	78.4	32.5*
			Chariton 2000–2001		
Control	86.22	82.6	9.08		9.08
Nov. 21	87.2	79.18	8.04		8.04
Dec. 19	82.9	79.13	7.92		7.92
Jan. 16	82.98	77.2	9.04		9.04
Feb. 13	83.6	76.9	8.33		8.33
Mar. 13	86.4	54.5*	4.08*		4.08*

*Indicates a significant difference ($P<0.05$) from control and grazed paddocks within column.

Table 3. Average subsoil depth and clay content for topsoil, midsoil, and subsoil.

	Atlantic 1999–2000	Atlantic 2000–2001	Chariton 1999–2000	Chariton 2000–2001
Average clay content, %				
Topsoil	21.4	30.0	32.1	32.6
Midsoil	22.4	30.4	32.2	33.7
Subsoil	33.0	40.0	34.6	40.3
Subsoil depth, inches	20.0	23.4	11.0	13.0

Table 4. Surface roughness measured as the standard deviation in length of 40 pins and % change in length of a 2-meter chain.

Initiation date for paddock	Standard deviation in pin length, cm	Reduction in chain length, %
	Atlantic 1999–2000	
Control	1.12	2.88
Oct. 18	1.19	3.56
Nov. 10	1.27	3.98
Dec. 08	1.33	4.85*
Jan. 05	1.24	3.02
Feb. 02	2.10*	9.48*
	Atlantic 2000–2001	
Control	2.11	2.90
Oct. 16	2.20	4.40
Nov. 13	2.06	2.50
Dec. 11	2.11	4.40
Jan. 08	2.04	3.40
Feb. 05	2.30	2.40
	Chariton 1999–2000	
Control	1.66	2.61
Nov. 29	1.32*	2.80
Dec. 28	1.29*	4.05*
Jan. 25	1.82	4.20*
Feb. 22	1.72	5.52*
Mar. 21	1.41	3.29
	Chariton 2000–2001	
Control	2.2	6.4
Nov. 21	1.8	6.2
Dec. 19	2.1	5.6
Jan. 16	2.4	6.6
Feb. 13	2.0	5.2
Mar. 13	3.5*	17.5*

*Indicates a significant difference (P<0.05) from control and grazed paddocks within column.

One characteristic of the soil that did show distinct differences resulting from grazing was soil surface roughness (Table 4). When measured either with a 40-pin meter or a 2-m chain, soil surface roughness in the last paddock grazed during the season was greater (P<0.05) than the ungrazed control paddock. This roughness seems to have resulted from hoof traffic on the paddock during a period when the soil was not frozen with adequate amounts of daily precipitation (Figures 3 and 5).

Although grazing did increase soil surface roughness, there was no main effect of grazing or grazing by tillage interaction on soybean yields in the year subsequent to grazing (Figure 7). This result indicates that whatever effect grazing may have had on soil roughness it did not affect soybean yield. Soybean yields were lower (P<.05) in no-tillageed fields than in tilled fields.

At the Atlantic site, the cows began the grazing season with an average BCS of 5.36/cow and a weight of 1,366 lbs./cow. When the cows were removed on March 1, they had an average BCS of 5.09 and weight of 1,455 lbs. per cow. Over the season, the cows had consumed supplemental hay totaling 14,330 lbs., and equaling 8.78 lbs./cow/day.

Atlantic, Iowa, Location 2000–2001

Similar to the first year, the initial corn crop residue dry matter yield and composition did not differ between fields and decreased over the winter season in grazed and ungrazed paddocks. However, unlike the initial year, there was no reportable difference between the loss rate for grazed and ungrazed paddocks (Table 1). The IVDOM and ADIN data has not been analyzed.

The corn crop residue data for the second year at the Atlantic site showed confusing results (Table 2). The initial residue cover for the first and third paddocks grazed were significantly higher (P<0.05) than the other paddocks. Post-grazing residue cover measurements indicated significant (P<0.05) removal from the first two paddocks, suggesting that some grazing effect coincides with above-freezing soil temperatures signifying no snow cover. However, post-planting residue cover data shows a reduction (P<0.05) in the last two paddocks grazed. This possibly could result from drilling soybeans.

Initial bulk density readings did not differ between paddocks for either the 0–4 in. or 4–8 in. depths. The post-grazing bulk density ratios of 15 ft. outside grazing exclosures over inside grazing exclosures were not significantly different in either grazed or ungrazed paddocks. The penetration resistance ratios did show a slight increase (P<0.05) in resistance force at the 0–4 in. depth for the first, second, forth, and fifth paddocks grazed when compared to the control paddock (Figure 1). Soil clay content did not differ between paddocks (Table 3), nor did the soil moisture at time of measurements, suggesting that increase in resistance in 4 of the 5 grazed paddocks could have resulted from grazing pressure.

Soil surface roughness data showed no significant difference between grazed and ungrazed when measured with either a 40-pin meter or a 2-m chain (Table 4). This probably is a result of below-freezing soil temperatures through the end of the grazing season, when precipitation was high (Figures 3 and 5).

Soybean yields the following year once again showed no difference between paddocks grazed and ungrazed when using no-tillage or conventional planting methods (Figure 7). The soybean yields on no-tillage ground were less than that of conventional (P<0.05).

Chariton, Iowa, Location 1999–2000

As in both years at the Atlantic location, initial crop residue yields and compositions did not differ between fields (Table 1). Over the grazing season, the change in crop residue organic matter yield was not significantly different between grazed and ungrazed paddocks. Interestingly, corn crop residue composition did show a decrease in the amount of crude protein for grazed paddocks but an increase in acid detergent insoluble nitrogen. This might indicate that the cattle are grazing the leaves of corn residue lower in lignin content and leaving the stalks where crude protein may be bound by high amounts of lignin. However, if higher proportions of lignin were in residue of the grazed paddocks, then ADF measurements would be significantly higher than in ungrazed paddocks.

Initial corn crop residue covers did not differ between paddocks; but, post-grazing and post-planting covers were significantly different (P<0.05) for all paddocks grazed when compared to ungrazed control paddocks, this shows some evidence of residue removal by grazing. When separating post-planting cover by tillage treatment, no-tillage shows no effect of grazing, although there is a trend towards a grazing effect.

Post-grazing bulk density ratios taken outside and inside the grazing enclosures showed no significance for date grazed. However, the ratios of penetration resistance measurements taken 15 ft. outside and inside the grazing enclosures to a depth of 4 in. were greater in the second forth and fifth paddocks grazed than in ungrazed paddocks (Figure 2). This indicates that soil compaction had occurred at the beginning and end of the grazing season. Although soil clay content differed for depths, it did not differ between grazed and ungrazed paddocks (Table 3), and neither did soil moisture at time of measurements.

Similar to the Atlantic site, soil roughness data collected for the Chariton location from both the 40-pin meter and 2-m chain method indicated a date grazed interaction (Table 4). The reason for this is not as clear as for the Atlantic site. Soil temperature data show that the periods grazed with the greatest amount of frozen days resulted in the roughest soil (Table 4 and Figure 4).

Although there may have been an interaction between date grazed and soil compaction or soil roughness, there was no evidence of grazing effect on soybean yield (Figure 8). However, as at the Atlantic site, there was a slight difference between soybean yields on no-tillage and tillage blocks (P=0.08). In this instance disking yielded less than no-tillage with 33.98 bu./acre and 35.09 bu./acre, respectively.

For the 140 days of grazing, the Chariton site used 1,950 lbs. of hay, equaling 1.16 lbs./cow/day. Due to the method of corn grain harvest, the amount of hay fed at the Chariton site was considerably less than that at the Atlantic site. The study began with the cows having an average BCS of 5 and a weight of 1,259 lbs. The study ended with the cows having an average BCS of 4.6 and an average weight of 1,195 lbs.

Chariton, Iowa, Location 2000–2001

In the second year at the Chariton location, at the beginning or during the season, there was no significant difference (P<0.05) between grazed and ungrazed paddocks for corn crop residue yield or composition (Table 1). Crop residue IVDOM and ADIN have not been analyzed.

Corn crop residue cover was greatly reduced (P<0.02) in the last paddock grazed in the season (Table 2). Because of warm temperatures and moderate rainfall (Figures 4 and 6) during the last few weeks, cattle traffic caused a large amount of the residue to be worked into the soil in the last paddock grazed. These conditions also caused substantially higher (P<0.05) soil surface roughness measurements in the last paddock when measured by either the 40-pin meter or 2-m chain method (Table 4).

As in the two grazing seasons at Atlantic and the first at Chariton, when grazed and ungrazed paddocks were compared, there was no difference between initial bulk density and the final bulk density ratios at either depth. Also, penetration resistance ratios and soil clay content displayed no differences at both depths between grazed and ungrazed paddocks (Figure 2 and Table 3). This was surprising, considering the large amount of hoof prints left in the last paddock grazed.

Due to a greater amount of snow cover compared to the first year at Chariton, the cows at Atlantic required a total of 15,320 lbs. of hay equaling 9.12 lbs./cow/day. The cows began the season with an average BCS of 7.64 and weight of 1,416.75 lbs. When replaced on March 19, they had an average BCS of 4.92 and weight of 1,340.5 lbs. The second group of cows had an initial average BCS of 4.72 and weight of 1,265.7 lbs. When the study finished, they had an average BCS of 4.33 and weight of 1,136 lbs.

The soybean yield data is still being processed.

Implications

Two years of completed data from this study has shown that grazing can affect some soil and corn crop residue properties. Grazing corn crop residue has been shown to reduce the amount of OM present on the field. In warm and wet weather conditions, grazing corn crop residue can increase soil surface roughness and decrease crop residue cover. Penetration resistance measurements have been significantly different between grazed and ungrazed paddocks; but it is unclear why these effects have occurred, since the bulk density data has shown no effect of grazing on soil compaction at any time. However, no matter what the effects of grazing may be on soil characteristics, there have been no effects on soybean yield the following year.

Acknowledgments

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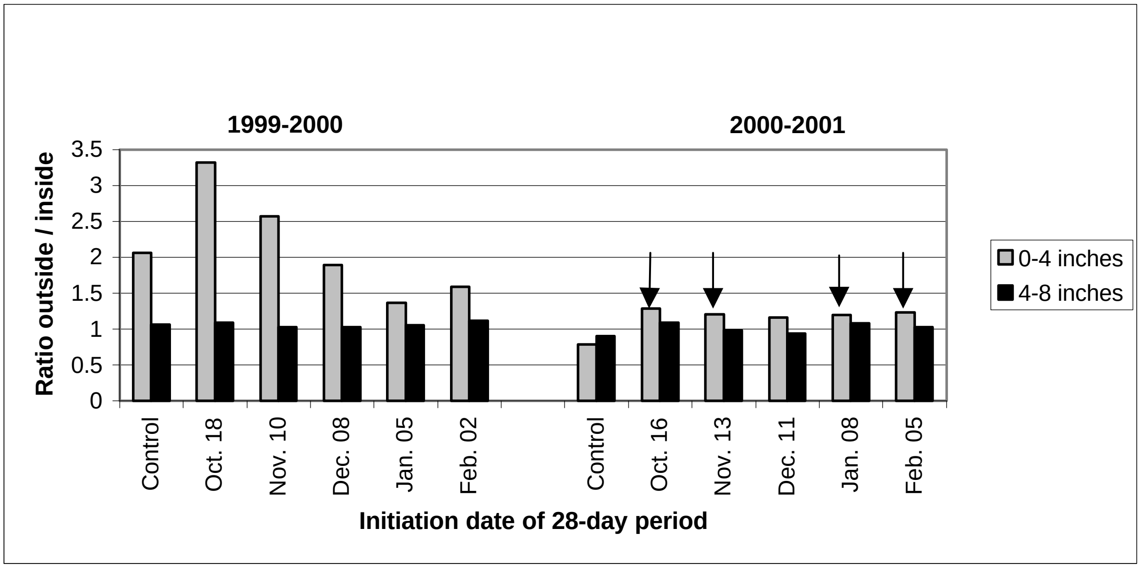
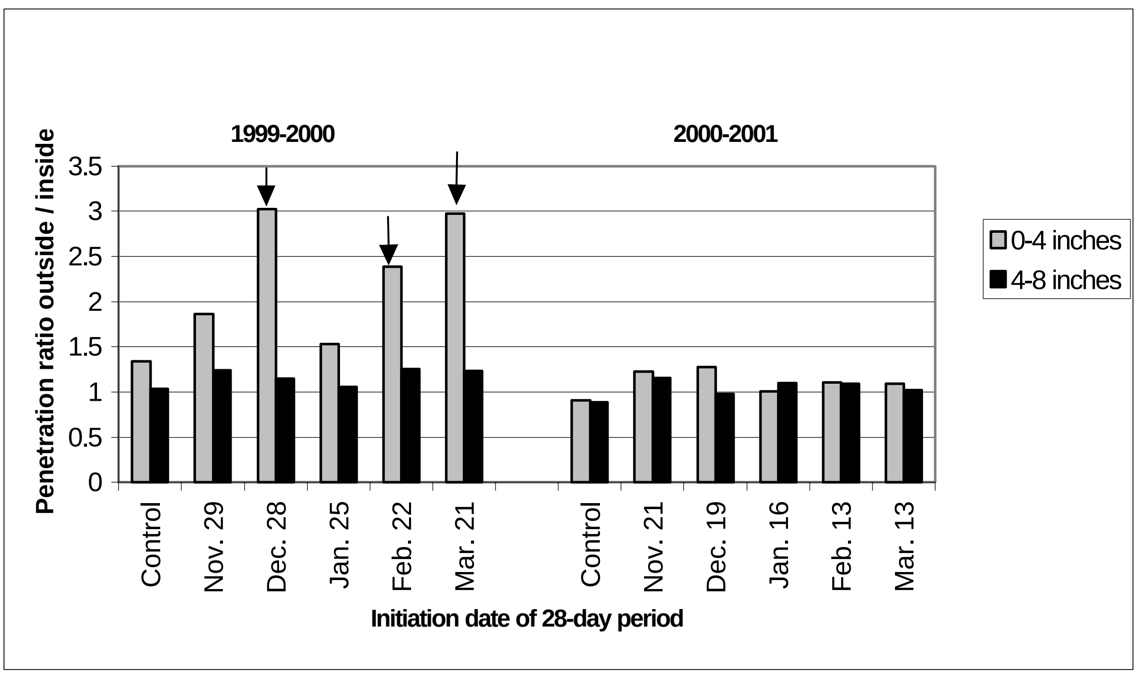
Figure 1. Atlantic penetration resistance ratio outside / inside grazing exclosure.



Arrow indicates a significant difference (P<0.05) from control paddock in that series.

Figure 2. Chariton penetration resistance ratio outside / inside grazing exclosure.



Arrow indicates a significant difference (P<0.05) from control paddock in that series.

Figure 3. Atlantic percent of time ground is frozen 1999–2000, 2000–2001.

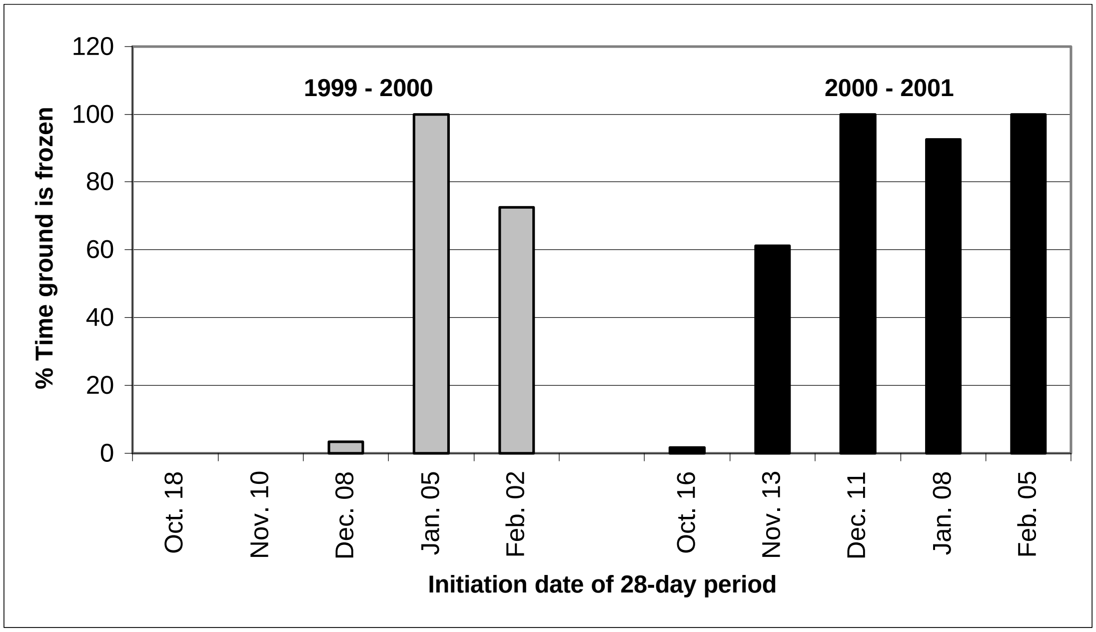


Figure 4. Chariton percent of time ground is frozen 1999–2000, 2000–2001.

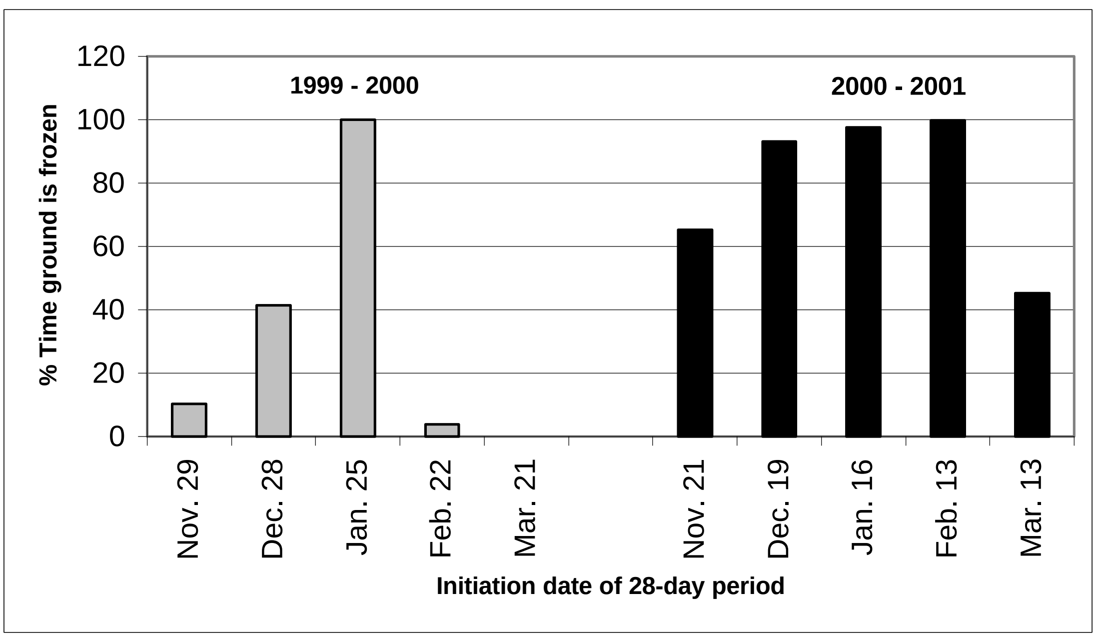


Figure 5. Atlantic daily average precipitation for 1999–2000, 2000–2001, and 30-year average.

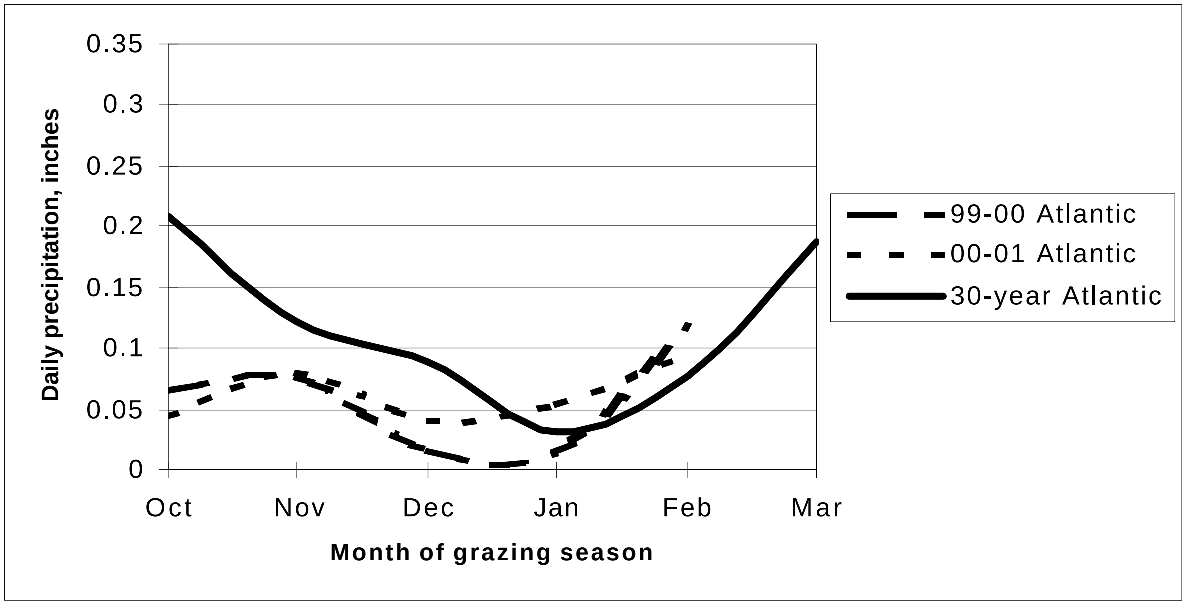


Figure 6. Chariton average daily precipitation for 1999–2000, 2000–2001, and 30-year average.

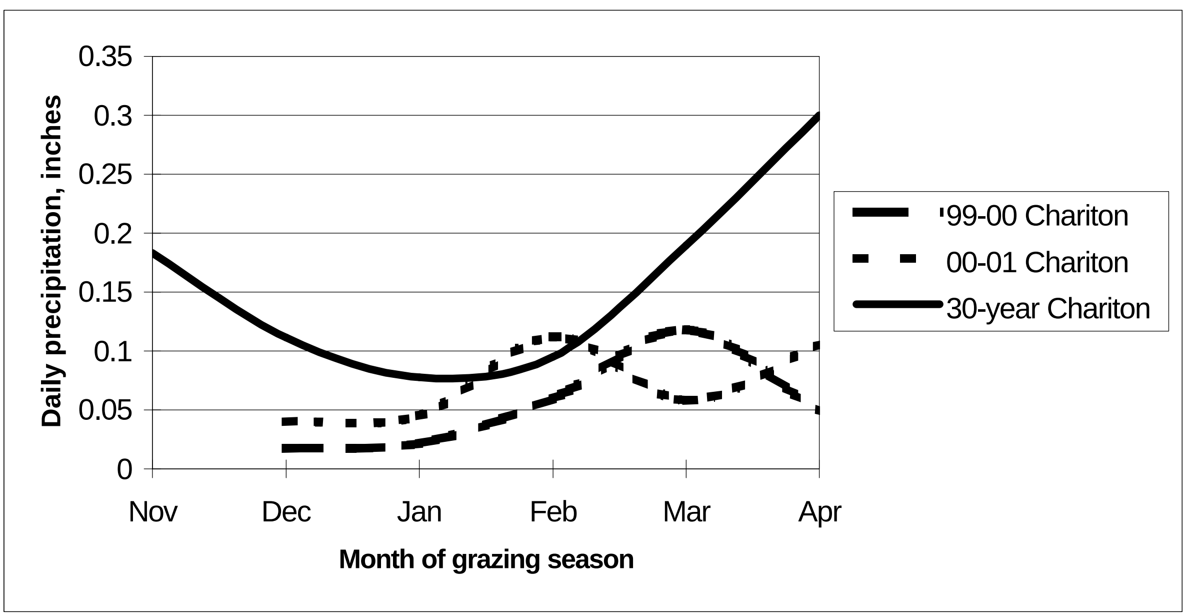
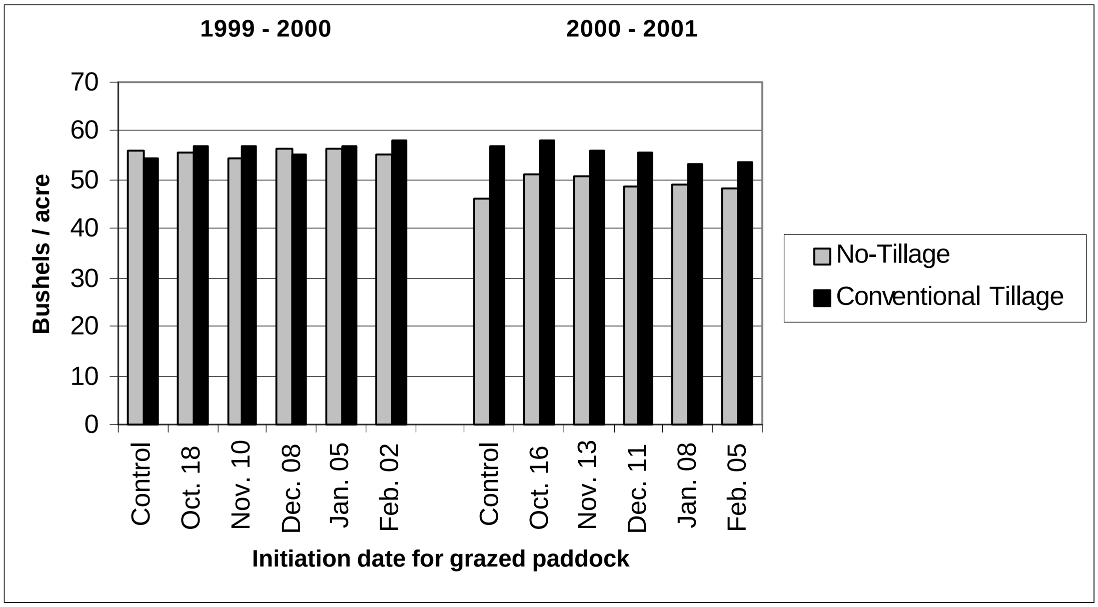
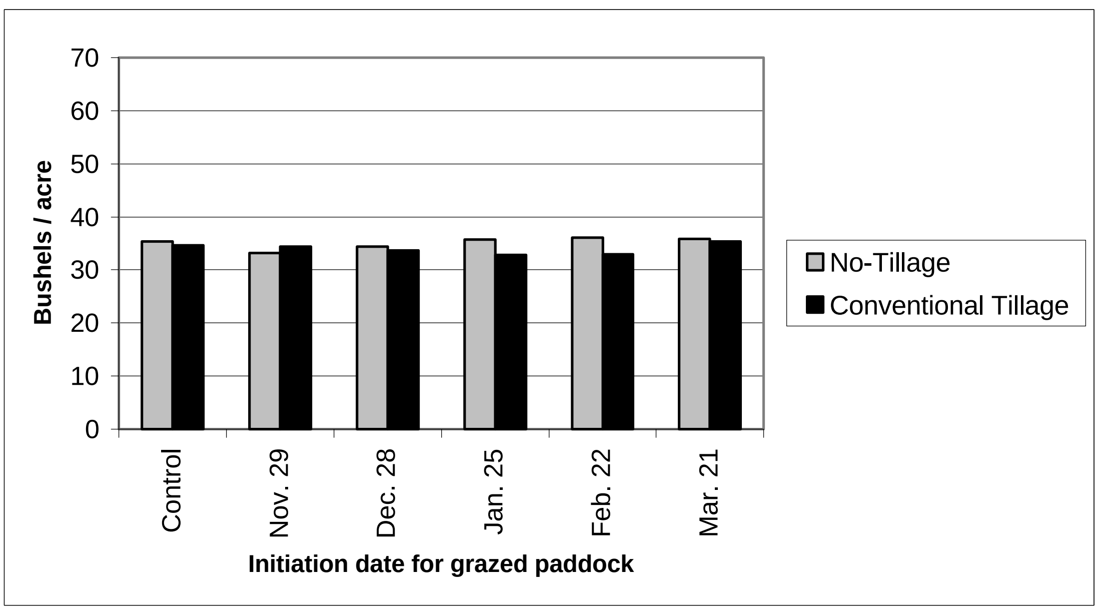


Figure 7. Atlantic soybean yield data 1999–2000, 2000–2001.



No significant difference (P<0.05) between paddocks grazed and control paddocks.

Figure 8. Chariton soybean yield data for 1999–2000.



No significant difference (P<0.05) between paddocks grazed and control paddocks.